

2017 APAAC Crash Conference

Event Data Recorders



Presented by:
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Why have an EDR

- ❑ Aviation EDR's
 - ❑ Marked decrease in aviation disasters after implementation.
 - ❑ Tells the rest of the story.
- ❑ Much more detail to collision investigation.
 - ❑ Automobile fatalities have significantly decreased since 2000.
 - ❑ Allows investigators to see driver intentions prior to impact.
 - ❑ Can't recreate real world crash pulses in a sterile lab environment.
- ❑ EDR's functions
 - ❑ Sense collision and fire airbags.
 - ❑ Monitor errors and faults in the airbag system.
 - ❑ Record crash data if necessary.



NHTSA Part 563

What is 563?

- Compliance request from NHTSA.
- Requires that IF a manufacturer has an EDR on vehicles manufactured after September 1, 2014 it must meet specific requirements.
- EDR defined as “a device or function in a vehicle that records the vehicle's dynamic **time-series** data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta-V vs. time), intended for retrieval after the crash event. For the purposes of this definition, the event data do not include audio and video data.”



NHTSA Part 563

- Who has EDR's?
 - 264 million vehicles registered in the US, 47% have an EDR with data accessible by the Bosch CDR system
 - 88% of 2015 model year vehicles have data accessible utilizing the Bosch CDR Tool®
 - 11% of 2015 model year vehicles have data accessible with some other tool.
 - Which manufacturers don't have data?
 - Ferrari, Porsche, Bentley and Alpha Romeo
 - Combined less than 1% of US market share.
 - Data has been recorded since 1994 model year on GM vehicles, making over 20 years of data available.
 - Key point, your vehicle(s) involved most likely have data stored in them.



NHTSA Part 563

Who has an EDR?

Make	Market Share	Year																							
		94	95	96	97	98	99	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
GM (CADILLAC,CHEVY,BUICK,GMC)	17.9%	SOME have EDR												All have EDR readable with Bosch CDR										FF	FF
FORD (LINCOLN, formerly MERCURY)	15.5%	Some, Not CDR												Some readable with Bosch CDR										All	All
TOYOTA (LEXUS, SCION)	14.4%	Some												All readable with Bosch CDR											
FCA (FIAT CHRYSLER, DODGE, JEEP, RAM, LA)	11.4%	Some												All readable with Bosch CDR											
HONDA (ACURA)	9.8%	?												?											
NISSAN (INFINITI)	7.9%	Not Bosch CDR - some																							
HYUNDAI	4.9%	? some												all											
VOLKSWAGEN (& AUDI)	4.0%	freeze frame data ?																							
KIA	3.9%	? some												all											
BMW (MINI, ROLLS ROYCE)	2.3%	?												?											
SUBARU	2.3%	?												freeze frame data ?											
DAIMLER(MERCEDES, MAYBACH, SMART)	2.0%	Non Bosch CDR - some												? some											
MAZDA (Former Ford partner)	1.9%	Non Bosch CDR - some												? ?											
VOLVO (Former Ford)	0.5%	Non Bosch CDR - some												?											
MITSUBISHI	0.4%	Non Bosch CDR - some												?											
JAG/LAND ROVER (Tata Motors India - Former Ford)	0.4%	Non Bosch CDR - some												?											
PORSCHE, BENTLEY (part of VW group) Bentley 201	0.2%	GM clone																							
SUZUKI (out of US market in 2015)	0.2%																								
MASERATI (FCA group)	0.0%																								
FERRARI (FCA group)	0.0%																								
SAAB	0.0%																								
LAMBORGHINI (VW group)	0.0%																								
ABARTH (FCA group)	0.0%																								
ALPHA ROMEO (FCA group)	0.0%																								

SOME have EDR ALL have EDR, CDR tool
 SOME EDR CDR All have EDR but not CDR tool



NHTSA Part 563

- What does EDR record?
 - Crash Pulse information
 - Longitudinal Δv
 - Lateral Δv
 - Longitudinal Acceleration
 - Lateral Acceleration
 - Time to deployment
 - Precrash data elements
 - Speed data
 - Accelerator Pedal Position
 - Brake Pedal
 - Steering wheel angle
 - Engine Speed (RPM)
 - Key point, your vehicle(s) involved most likely have data stored in them.



NHTSA Part 563

What does EDR record?



Major Data Elements by Manufacturer (All Mfrs with EDR have the required 15 data elements, all are not listed)
 Information is taken from Bosch CDR sample files and 2012 MY practice projected into 2013 model year

Mfr	Part 563 Table 1				Part 563 Table 2						Beyond 563								
	Event Complete	Key Cycles	Long. ΔV	Speed/Brake/Throttle or Accel	Multi Event	Lateral ΔV	RPM	Steering Angle	ACM Acceleration	ABS on/off	Roll Angle	ESC Long Accel	ESC Lat Accel	Yaw Rate	Tire Pressure	Panic Brake Assist	Wheel Speeds	Roll Rate	Brake Pressure
Bosch CDR																			
GM	X	X	X	5@0.5 TA	X	X	X	-	X, Y, Z 300@2			-						1 @ 10ms	
Ford	X	X	X	5@0.5 A	X	X	X	5@0.1	-	X		5@0.1		5@0.1	LO			5@0.1	
Chrysler	X	X	X	5@0.1 TA	X	X	X	5@0.1	-	X				5@0.1	PSI	X	X		
Toyota	X	X	X	5@0.5 TA	X	Side	X	5@0.5	-	?	?	5		5@0.5	-	-	-	In Roll	5@0.5
Honda	X	X	X	5@0.5 TA	X	X	X	5@0.5	X, Y, Z 250@10	X	-1+5@0.1	-		-	-	-	-		
Nissan	X	X	X	5@0.5 A	X	X	X	5@0.5	X, Y 250@10			-		-	-	-	?		
Mazda	X	X	X	5@0.5 T	X	X	X	5@0.5	X, Y 250@10			-		-	-	-	-		
Suzuki	X	X	X	5@0.5?	X	?	X	?	?	?	?	?		?	?	?	?		
Volvo	X	X	X	5@0.5T	X	-	-	-	X,Y,Z 250@10	-	-1+0.3@0.1								
BMW	X	X	X	5@0.5A	X	X	X	5@0.5	X, Y 300@10ms	X									
Hyundai	X	X	X	5@0.5	X	X	X	5@0.5	X,Y,Z 250@10	X	-1+5@0.1	-		-	-	-	-		

T= Throttle A= Accelerator Pedal position
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[Column E: 5@0.1 means 5 seconds of data at 0.1 second intervals](#)
[Column J: 300@2 means 300ms of acceleration data at 2ms intervals](#)



What's Important

- What needs to be done to reconcile the EDR file?
 - Is the recording complete?
 - Do my ignition cycles, (if available), match up?
 - Does the Δv match up and if acceleration data is available is the crash pulse complete?
 - Does my speed at impact match my reconstruction?
 - Is there a speed at impact calculation?
 - Does this file pass the common sense test?



Is the Recording Complete?

System Status at Event (First Record)

Complete File Recorded (Yes,No)	Yes
Multi-Event, Number of Events	1
Time From Event 1 to 2 (msec)	0
Lifetime Operating Timer at Event Time Zero (sec)	15,385
Key-On Timer at Event Time Zero (sec)	105
Vehicle Voltage at Time Zero (V)	13.7
Energy Reserve Mode Entered During Event (Yes, No)	No



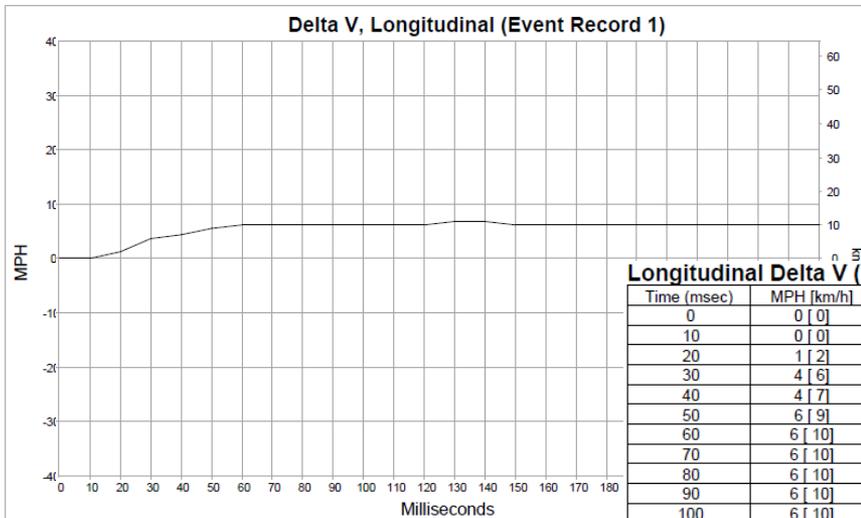
Do the ignition cycles match?

System Status at Time of Retrieval

VIN As Programmed into RCM at Factory	1FA6P8CF5F [REDACTED]
Current VIN from PCM	1FA6P8CF5F [REDACTED]
Ignition Cycle, Download (First Record)	270
Ignition Cycle, Download (Second Record)	270
Restraints Control Module Part Number	FR3T-14B321-AF
Restraints Control Module Serial Number	7005167300000000
Restraints Control Module Software Part Number (Version)	FR3T-14C028-AC
Driver Side/Center Frontal Restraints Sensor Serial Number	00C1177A
Driver, Row 1, Side Restraint Sensor 1 Serial Number	0000009A
Driver, Row 2, Side Restraint Sensor 2 Serial Number	00B5177A
Passenger Frontal Restraints Sensor Serial Number	00AD17BD
Passenger, Row 1, Side Restraint Sensor 1 Serial Number	000000A4
Passenger, Row 2, Side Restraint Sensor 2 Serial Number	00B317EC

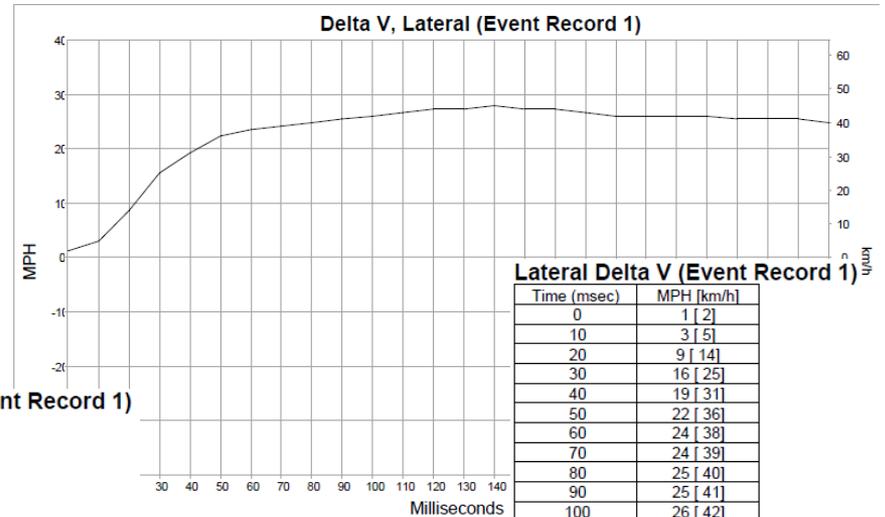


Does the Δv match?



Longitudinal Delta V (Event Record 1)

Time (msec)	MPH [km/h]
0	0 [0]
10	0 [0]
20	1 [2]
30	4 [6]
40	4 [7]
50	6 [9]
60	6 [10]
70	6 [10]
80	6 [10]
90	6 [10]
100	6 [10]
110	6 [10]
120	6 [10]
130	7 [11]
140	7 [11]
150	6 [10]
160	6 [10]
170	6 [10]
180	6 [10]
190	6 [10]
200	6 [10]
210	6 [10]
220	6 [10]
230	6 [10]
240	6 [10]
250	6 [10]



Lateral Delta V (Event Record 1)

Time (msec)	MPH [km/h]
0	1 [2]
10	3 [5]
20	9 [14]
30	16 [25]
40	19 [31]
50	22 [36]
60	24 [38]
70	24 [39]
80	25 [40]
90	25 [41]
100	26 [42]
110	27 [43]
120	27 [44]
130	27 [44]
140	28 [45]
150	27 [44]
160	27 [44]
170	27 [43]
180	26 [42]
190	26 [42]
200	26 [42]
210	26 [42]
220	25 [41]
230	25 [41]
240	25 [41]
250	25 [40]



Does Speed at Impact Match?

- What is speed at Impact?
 - The recording speed occurs before the crash in nearly all cases.
 - You must reconcile for the time.
 - A skidding vehicle can lose 15MPH/sec.





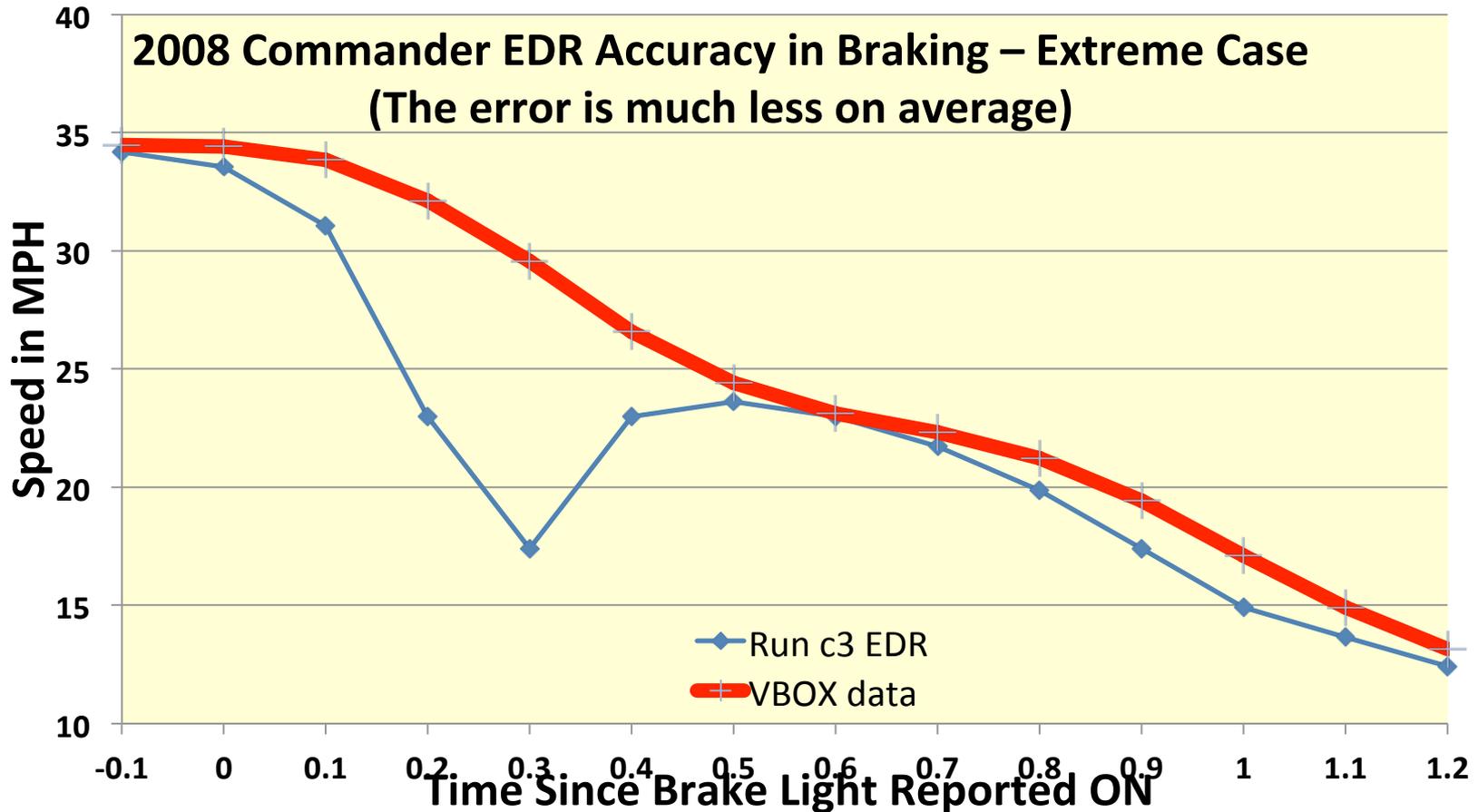
Does Speed at Impact Match?

- What is speed at Impact?
 - The recording speed occurs before the crash in nearly all cases.
 - You must reconcile for the time.
 - A skidding vehicle can lose 15MPH/sec.
 - Possible error for Speedometer, and ABS.





Does Speed at Impact Match?





Does Speed at Impact Match?

- What is speed at Impact?
 - The recording speed occurs before the crash in nearly all cases.
 - You must reconcile for the time.
 - A skidding vehicle can lose 15MPH/sec.
 - Possible error for Speedometer, and ABS.
 - Answer will yield a speed range.



Does Speed at Impact Match?

Momentum Analysis

Data

Cavalier

Minivan

$$\alpha = 0^\circ$$

$$\psi = 90^\circ$$

$$\theta = 29^\circ$$

$$\varphi = 51^\circ$$

$$v_3 = 36\text{MPH}$$

$$v_4 = 38\text{MPH}$$



Momentum Range:

64 to 75 MPH



Does Speed at Impact Match?

EDR Analysis

- Last Data Point: 67 67
- +/- ABS: N/A N/A
- Braking: - 15 - 0
- Speedo Error: -2.6 + 2.6
- 49 to 69



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle
-5	69	3456	96
-4	71	3136	0
-3	70	3008	0
-2	70	2816	0
-1	67	2688	0

Brake Switch indicates off until -1 second.



Does Speed at Impact Match?

Momentum
Analysis

Min:
64MPH
Max:
75 MPH

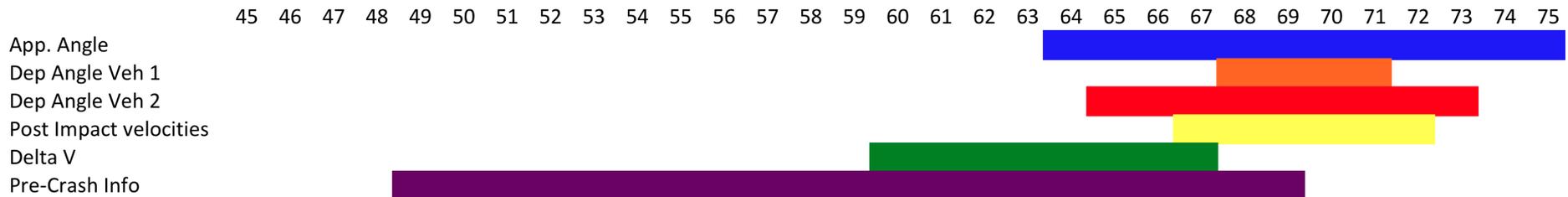
EDR
 Δv

Min:
60 MPH
Max:
67 MPH

EDR
Pre-crash

Min:
49 MPH
Max:
69 MPH

- ✓ What is the Speed range you should use?
 - ✓ Overall range 49-75
 - ✓ 67 - 68 is compelling to the lay person.
 - ✓ The Speeds most closely overlap in this range.





Using Victim EDR for Suspect Speed

Momentum Analysis

Data

Volkswagen

Lexus (EDR)

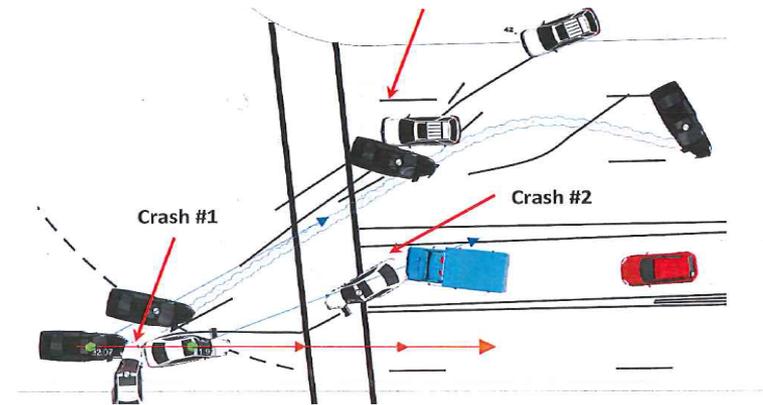
$$\alpha = 0^\circ$$

$$\psi = 90^\circ$$

$$\theta = 32^\circ$$

$$\varphi = 22^\circ$$

$$v_3 = 41.93 \text{ MPH} \quad v_4 = 42.94 \text{ MPH}$$



Momentum Range:

Volkswagen: 70-84 MPH

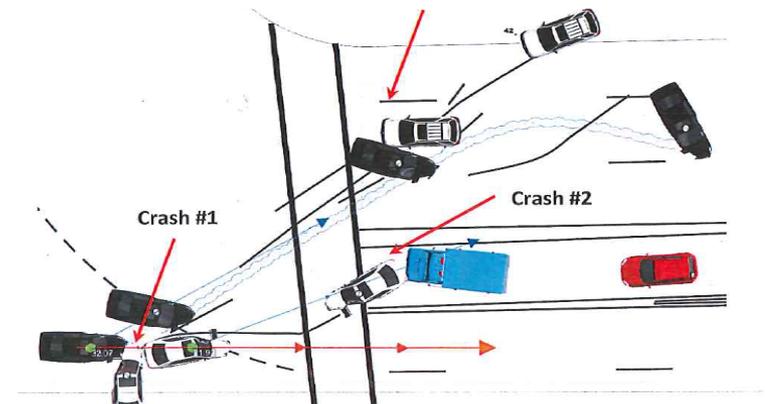
Lexus: 30-43 MPH



Does Speed at Impact Match?

Pre-crash EDR Data Analysis

- Last Data Point: 37.3 37.3
- +/- ABS: N/A N/A
- Braking: - 0 - 0
- Speedo Error: -1.49 + 1.49
- 35.8 to 38.7



Pre-Crash Data, -5 to 0 seconds (Most Recent Event, TRG 2)

Time (sec)	-4.7	-3.7	-2.7	-1.7	-0.7	0 (TRG)
Vehicle Speed (MPH [km/h])	36 [58]	37.3 [60]	37.3 [60]	37.3 [60]	37.3 [60]	37.3 [60]
Brake Switch	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator Rate (V)	1.21	1.25	1.21	1.13	1.17	1.25
Engine RPM (RPM)	1,200	1,200	1,200	1,200	1,200	1,200

Vehicle in a steady state throughout recording

Momentum Range:
 Volkswagen: 70-84 MPH
 Lexus: 30-43 MPH

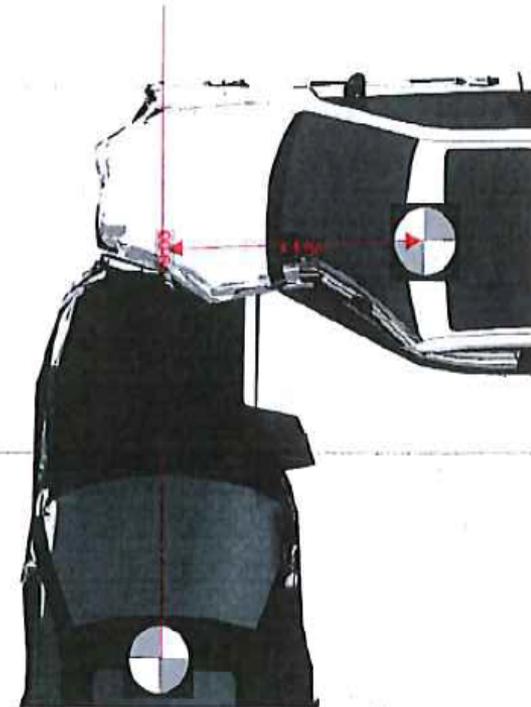


Impact Speed from Victim EDR

Δv EDR Data Analysis

Lateral Crash Pulse (Most Recent Event, TRG 2 - table 2 of 2)

Time (msec)	Lateral Delta-V, Airbag ECU Sensor (MPH [km/h])	Lateral Delta-V, B-Pillar Sensor (MPH [km/h])	Lateral Delta-V, C-Pillar Sensor (MPH [km/h])
-23	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-19	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-15	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-11	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-7	0.0 [0.0]	0.0 [0.0]	0.0 [0.0]
-3	-0.1 [-0.2]	0.0 [0.0]	0.0 [0.0]
1	0.1 [0.1]	0.0 [0.0]	0.1 [0.1]
5	0.7 [1.1]	0.0 [0.0]	0.1 [0.1]
9	2.0 [3.3]	0.3 [0.4]	0.1 [0.1]
13	3.7 [6.0]	1.0 [1.7]	0.2 [0.3]
17	5.0 [8.0]	2.3 [3.7]	0.8 [1.2]
21	6.5 [10.5]	3.5 [5.6]	1.5 [2.3]
25	8.2 [13.2]	6.3 [10.1]	2.1 [3.3]
29	9.9 [16.0]	7.8 [12.6]	2.7 [4.4]
33	11.7 [18.8]	10.0 [16.1]	3.8 [6.1]
37	13.4 [21.6]	13.6 [21.9]	4.9 [7.9]
41	15.1 [24.4]	15.9 [25.7]	6.9 [11.0]
45	16.5 [26.5]	19.2 [30.8]	8.7 [14.1]
49	17.4 [28.0]	22.0 [35.4]	9.6 [15.4]
53	18.6 [30.0]	23.0 [37.0]	10.8 [17.4]
57	19.7 [31.7]	23.0 [37.0]	11.8 [19.0]
61	20.5 [33.0]	23.8 [38.3]	12.5 [20.1]
65	20.9 [33.7]	25.2 [40.6]	13.1 [21.1]
69	21.1 [33.9]	26.2 [42.2]	13.8 [22.2]





Impact Speed from Victim EDR

Isolate the post-impact longitudinal Δv of suspect vehicle

$$\Delta v_{3x} = v_3(\cos\theta)$$

$$\Delta v_{3x} = 41.93(\cos(32^\circ))$$

$$\Delta v_{3x} = 41.93(0.848)$$

$$\Delta v_{3x} = 35.55\text{mph}$$

+/- EDR Error

$$v_{\text{impact}} = \pm\Delta v_{\text{Error}} + \Delta v_{\text{EDR}} + v_{3x}$$

$$v_{\text{impact}} = \pm 3.9 + 35.55 + 42.58$$

$$v_{\text{impact}} = 74.23 - 82.03\text{MPH}$$

Calculate the Volkswagen Δv_x based on Lexus Δv_y

$$v_{x\text{volks}} = \Delta v_{y\text{Lexus}} \frac{W_{\text{Lexus}}}{W_{\text{Volks}}}$$

$$v_{\text{impact}} = 39.8 \frac{3695}{3440}$$

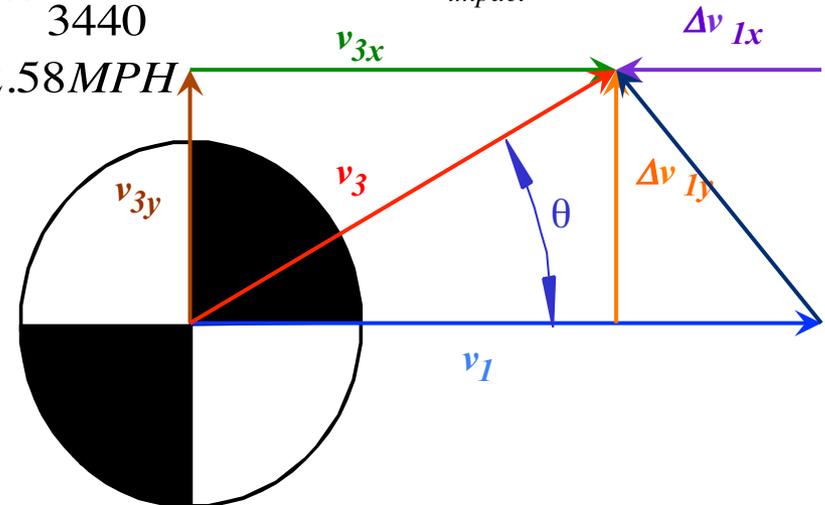
$$v_{\text{impact}} = 42.58\text{MPH}$$

Add Longitudinal Δv and lateral victim EDR Δv

$$v_{\text{impact}} = \Delta v_{y\text{EDR}} + v_{3x}$$

$$v_{\text{impact}} = 42.58 + 35.55$$

$$v_{\text{impact}} = 78.13\text{MPH}$$



*Note that EDR Lateral Δv must be adjusted for effective mass ratio



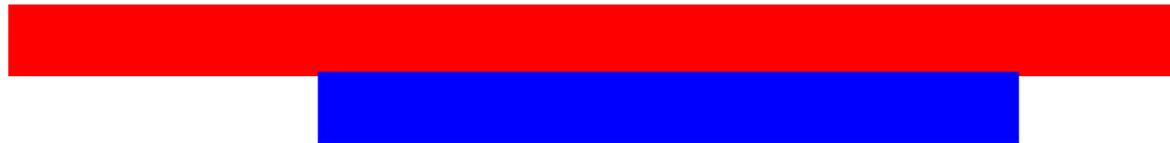
Impact Speed from Victim EDR

Momentum Analysis		EDR Δv	EDR Pre-crash
Suspect	Victim	Suspect	Victim
Min: 70 MPH	Min: 30 MPH	Min: 74 MPH	Min: 36 MPH
Max: 84 MPH	Max: 43 MPH	Max: 82 MPH	Max: 39 MPH

- ✓ What is the Speed range you should use?
 - ✓ Overall range 70-84
 - ✓ 74 - 82 is compelling to the lay person.
 - ✓ The Speeds most closely overlap in this range.
 - ✓ My Speed range was 78

68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85

Momentum
EDR





What do you need to know?

- ❑ IS the vehicle involved covered?
- ❑ Has the .cdrx file been opened in the most recent version of the software?
- ❑ Is your recording complete?
- ❑ Has a speed at impact analysis been completed?



What research is available?

- SAE World Congress every year includes an entire segment on Passenger Vehicle Event Data Recorders.
 - Some of these include quantifying Δv data and pre-crash data
 - Survivability of EDR's in fires, water, etc.
- Accident Reconstruction Journal and Collision Magazine are also good resources.



Legal Matters

- ❑ Was the information collected legally?
- ❑ Was the evidence properly preserved?
- ❑ Is this recording from the event being investigated?
- ❑ Does the data meet the Daubert standard?



Collected Legally?

- Search Warrant
 - California V Diaz
 - Defendant found to have a BAC of 0.20%.
 - One year later, vehicle in police impound was imaged.
 - Found vehicle to be going 73 in 50 mph zone.
 - Defendant charged with 2nd Degree Murder and Vehicular Manslaughter.
 - Found guilty of involuntary manslaughter, 10 year sentence.
 - California court of appeals found the search of the EDR to be valid stating in part that Diaz had knowingly exposed her speed and brake application to the public by driving.
 - Agrees with NY v. Christmann 2004
 - BUT, we can find a state with a differing opinion for every one of these opinions, so if you can, get a warrant.



Properly Preserved?

- ❑ In most instances the data cannot be overwritten.
- ❑ What is the chain of custody for the vehicle if the module has been left in the vehicle?
- ❑ If the module is removed and put into evidence, was it done properly?



Relevant Event?

- As discussed briefly
 - Complete recording?
 - Ignition Cycles match?
 - Does the data match the crash?
 - Has the common sense test been conducted?



Meet Daubert?

- ❑ Can this technique be tested?
 - ❑ Yes
 - ❑ Too many SAE papers to list.
- ❑ Subject to peer review evaluations?
 - ❑ SAE, peer reviewed.
 - ❑ Collision Magazine, peer reviewed.
- ❑ Error known for technique?
 - ❑ Error rates known and published.
- ❑ Generally accepted in the field?
 - ❑ Yes, every crash reconstruction conference has something about EDR's.

Questions?